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Development of a Graduate On-Line Certificate Program in Engineering Education*

JACEK UZIAK
Department of Mechanical Engineering, University of Botswana, P/Bag UB0061 Gaborone, Botswana.
E-mail: uziak@mopipi.ub.bw

RYAN BARLOW, IDALIS VILLANUEVA, OENARDI LAWANTO and KURT BECKER
Department of Engineering and Technology Education, Utah State University, 4100 Old Main Hill, Logan, UT 84322–6000, USA.

The paper describes the development of an online Engineering Education Graduate Certificate program. The program targets current and future engineering educators, both in academia (community colleges and universities) and industry. The goal is to improve the quality of engineering teaching and training by empowering students to become better and more knowledgeable engineering instructors through their understanding of educational theories and applications. The program intends to be fully online, with a combination of asynchronous and synchronous instruction.

Keywords: engineering education; graduate certificate; online education

1. Introduction

The focus of institutions that house a College of Engineering is to help students attain an academic degree in engineering from a bachelor's degree to a doctorate. Universities typically offer bachelor's, master's, and doctoral programs. A community college typically offers two years of college classes. It offers courses, which can be used for general education requirements. That can be followed by a transfer to a four-year university to finish your bachelor's degree [1].

To become a professional engineer, completing a professional registration exam is an expectation in many engineering disciplines (i.e., Civil Engineering) [2] if the professional path involves consulting or working in industry [3]. In academia, however, professional certification is not a requirement [4]. In the same vein, educational certification for engineers in academia is not required [5]. Upon entry to an educational institution, engineering faculty and educators rely on sparse and short trainings to educational theories and teaching methods [6], if the institution offers such service [7]. The inconsistency and lack of resources for engineering educators on evidence-based pedagogy creates a void that can hinder ways that engineering students can optimally be prepared to become professional practitioners in the 21st century [8]. This pedagogical concern becomes even more apparent in an online learning environment. The rapid growth of online learning programs has prompted the need to rethink pedagogical practices that were once appropriate [9].

Regarding education, engineering as a field is behind the times. Astin conducted a study on the types of instructions done by professors across disciplines and found that engineering classes use lecture as the most common form of teaching [10]. In 2006, Lattuca, et al. conducted a similar study and found that engineering classes still use lecturing and that the decrease in this form of teaching was modest [11]. Pomales-Garcia and Liu found that engineering students want less lecturing and more engineering applications, examples and chances to work in the class [12]. Wankat and Oreovicz [13] found that lectureship continues to be the predominant form of teaching among engineering educators, although assistant professors are beginning to explore active learning methods and incorporate them in their classrooms. These findings suggest that there is reluctance by engineering educators to change their pedagogical styles. Furthermore, according to Svedberg [14], ''teachers in engineering at universities tend to teach in the same way as they have experienced during their own studies''. He analyzed the classical teaching culture in engineering education and compared it to a set of six teaching principles. Based on this analysis, he concluded that ''teachers adhering to the traditional teaching culture in engineering cannot possibly obtain good or effective teaching'' [14]. The problem of classical teaching culture perpetuated through generations can be safely blamed on insufficient training in proper teaching practices for engineering educators. Though Svedberg was specifically discussing engineering educators at universities, the same conclusions apply to those at academic institutions and engineering trainers in industry. One of the reasons for this unwillingness to change is lack of resources available across institutions regarding pedagogy [15–16] as well as lack of incentives (e.g.,

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certifications) that can enhance the engineering educators' skillsets [17].

Integrating theory and practice is important in any professional program, and active learning is used to enhance the integration of practice and theory in the classroom [18]. However, this type of pedagogical approach is typically alien to traditional teaching in engineering.

Professional development for educators is not new, even for engineering educators. Such programs exist in several forms, including graduate engineering education certificate programs [19]. However, those that are available are primarily directed at STEM education [20]. The limited number of programs specifically designed for engineering educators tends to be limited to the faculty or students at that particular university and use face-to-face instruction.

A graduate certificate program under development at the Utah State University offers a widespread dissemination via online instruction to a wide range of institutions, both in academia and industry worldwide. This study presents the development of an online certificate program for engineering professionals employed in positions of pedagogical leadership and training.

Undergraduate degrees in engineering education are typically not offered [21]. As such, the preparation of engineering educators down the "pipeline" to Ph.D. is limited. This also limits the potential success that many engineering educators could have as both a technical expert and an educational expert.

Postgraduate degrees at the Master's or Ph.D. level in engineering education have the aim of not only preparing a graduate student to teach, but also to conduct and direct research in the area of engineering education [19]. The programs, which directly educate students in the theory and application of engineering education, are graduate (or postgraduate) certificates [22]. Certificate programs have grown in popularity, especially for professionals with time and financial limitations, and many universities offer such programs in areas such as business, education, health care, and technology [23]. In the recent years, such programs also acquired a better recognition and understanding of their value and changed the original negative comprehension of such programs [24]. However, hardly any other graduate program, apart from Master's or Ph.D., is offered in the area of engineering education outside of the USA [25].

2. Existing programs and needs assessment

2.1 Content analysis of graduate certificate programs in engineering education

A detailed quantitative content analysis of engineering education certificate programs (and to some extent in STEM) was performed for four-year institutions across the United States. Content analyzed included the institutional program websites and papers, either published or presented in conferences, related to those programs. Findings revealed that few institutions provide certificate programs at graduate certification level (Table 1). Out of those that offer such programs, Purdue [26] include only core classes (mainly on pedagogy) whereas University of St. Thomas [27] and Tufts University [28] do not have a teaching internship or practicum. On the other hand, most of the certificate programs, such as at Virginia Tech [29], Clemson University [30], University of Texas at Austin [31] and Wichita University [32] include teaching internship or practicum.

The only graduate certificate program fully online is offered at Tufts University [28]. It is also the only program that is specifically intended for current K-12 teachers. None of the other programs are specific to either K-12 or post-secondary engineering education. The program at Tufts requires students to take four core courses with no electives and does not involve any teaching internship or practicum.

2.2 Needs assessment of graduate certification for engineering education programs in academia and industry

In order to determine the need or desire for an engineering education professional development program, a needs assessment survey was developed and conducted. The survey was based on discussions between engineering educators and professional communications with instructors. It went through several rounds of content validity involving faculty members and an English language expert before it was launched with participants from industry and from 2-year and 4-year colleges from across the USA.

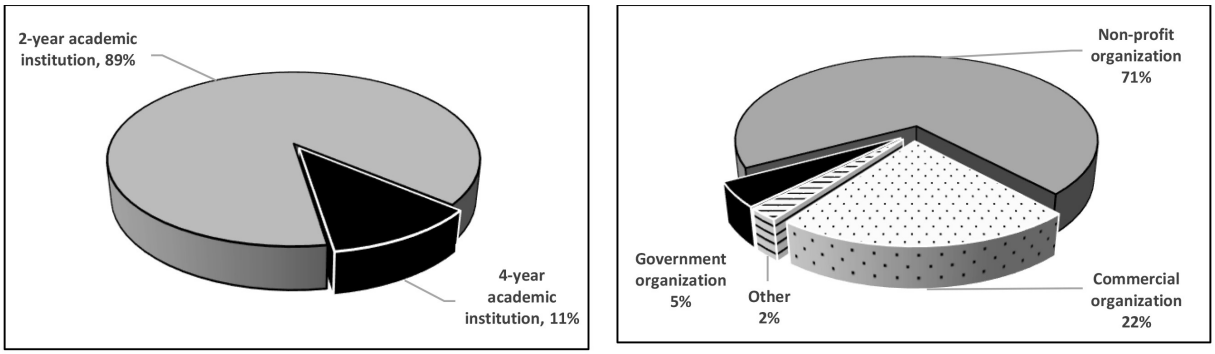
Needs assessment survey was sent to human resource representatives from industry and from academic institutions. There were 191 responses to the survey; 86 from industry and 105 from academic institutions (see Fig. 1 for breakdown of participants' organization types). Most responses (85%) were received from the West/Mid-West region of the United States, and results presented in this work reflect these findings. The participants of the survey were asked several questions related to the professional development for engineering educators.

The needs assessment survey also included questions about preferred professional development program type, length for each program type, delivery method, and preferences of the content of the program.

Table 1. Graduate Certificate Programs in Engineering Education

Institution	Academic Unit	Requirements	Comments
Purdue University	School of Engineering Education	• 10 credits* • All core courses, 3 on pedagogy • A semester-long Mentored Teaching Experience course (1 credit)	• Teaching and Learning in Engineering Graduate Certificate • Admission requirement Bachelor's degree from an accredited institution
Virginia Tech	Department of Engineering Education	• 13 credits • Core courses on engineering pedagogy • Practicum in the Engineering Classroom course • Required 1 course from Pedagogy List • Elective list includes more research focused courses	• Engineering Education Graduate Certificate • Admission requirement include either enrolment in masters or doctoral program or Bachelor's degree in any engineering field or Mathematics / Physical or Biological Sciences
Clemson University	Department of Engineering & Science Education	• 11 credits • 1 credit hour Practicum • Courses in Pedagogy, Educational research Methods and Professional Preparation	• Certificate in Engineering and Science Education • Admission requirement include enrolment in doctoral program
University of Texas	Cockrell School of Engineering	• 16 credits • Core courses on pedagogy: some undergraduate • One elective course in education of engineering education • Teaching Practicum course (6 credits) and Teaching Portfolio Prep course (1 credit)	• Graduate Certificate in Engineering Education • Certificate credits may also be counted toward a degree
University of St. Thomas	Center for Engineering Education	• 12 credits • 3 core graduate courses including Engineering Design • 1 elective course	• STEM Graduate Certificate in Engineering Education • Designed for in-service P-12 educators
Wichita State	College of Education & College of Engineering	• 12 credits • 3 core graduate courses on pedagogy • Internship course	• Graduate Certificate in Engineering Education • Admission limited to Engineering graduate students

* Credit—refers to academic credit that normally represents approximately three hours of work per week by an average student throughout a normal semester.



(a) Academic institutions (b) Industry

Fig. 1. Organization Types, Number of Participants and Survey Participants.

Concerning the preferred program type (Fig. 2); for the industry participants a certificate program was the most preferred program type (49%) with a Master's Degree program second (40% participants). For the academic institution participants, a certificate program was also the most preferred program type (45%) with a Doctorate Program in close second (38%).

Since the certificate program was the preferred program type for both industry and academic institution participants, only the preferred length of the certificate program was included below as Fig. 3. It is clear that a short certificate program of up to 12 months was preferred over a longer program for both industry and academic institution participants.

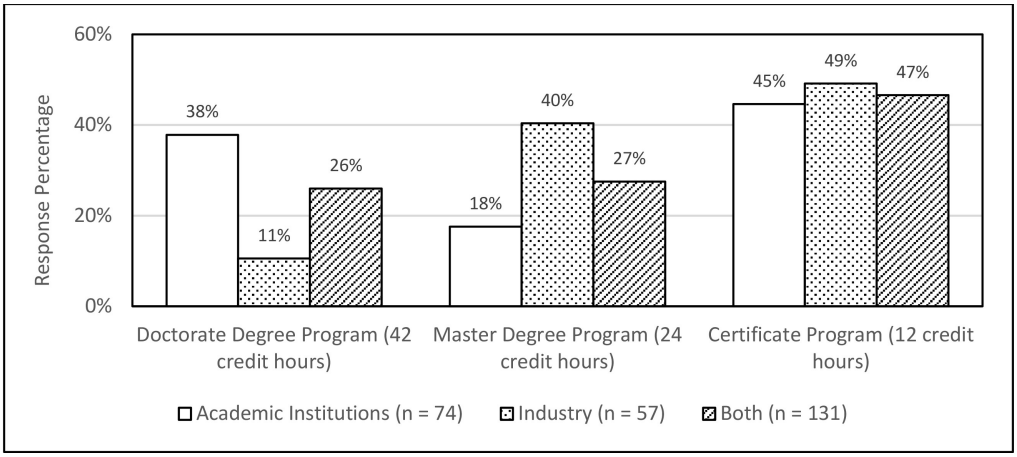


Fig. 2. Preferred Professional Development Program Type.

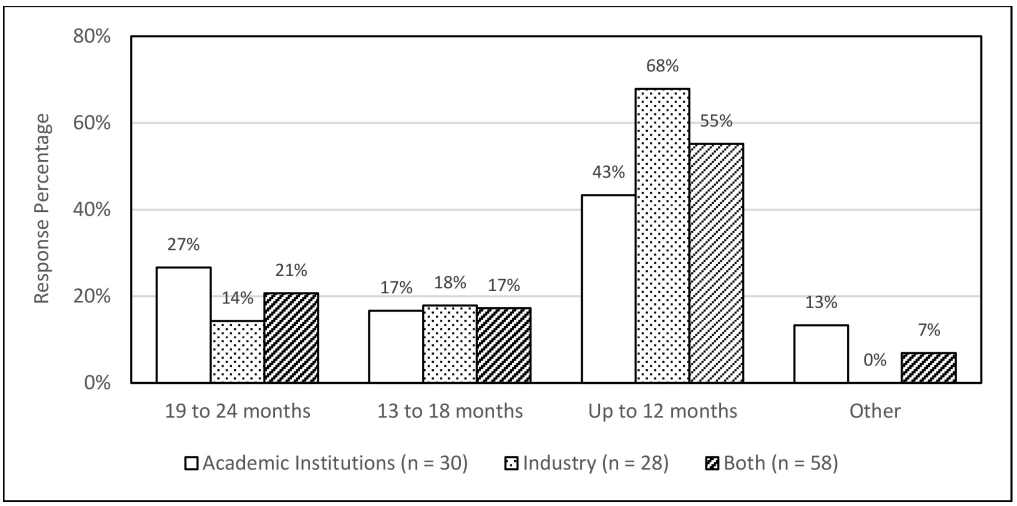


Fig. 3. Preferred Length for Professional Development Certificate Program.

The needs assessment survey also asked the participants which delivery method would be preferred for the planned engineering education professional development program. Fig. 4 shows the results of this question. The preferred method for both industry and academic institution participants was Online Option B: A Combination of Asynchronous and Synchronous. Face-to-face was in a close second in both industry and academic institution, but this delivery method limits the instruction to those in close proximity to the campus. Between the online options, a combination of synchronous and asynchronous instruction was clearly preferred over asynchronous instruction both, by both industry and academic institution participants.

The needs assessment survey requested the participants to rank the importance of four different subject areas for inclusion in an engineering education professional development program: Curriculum Design, Evaluation and Assessment, Principles of Teaching and Learning, and E-learning Course and Training Development. A weighted ranking calculated by using the frequency of answers for each topic is presented in Fig. 5.

The weighted ranking for each subject area was approximately 25% (+/− 5%), meaning that each topic has a similar amount of importance to the participants.

3. Design of curriculum based on preliminary results

Based on the results of the needs assessment survey, a Graduate Certificate Program in Engineering Education has been designed and is in the process of being implemented by a curriculum team consisting of faculty within the Department of Engineering Education at Utah State University. Based on the results of the survey regarding preferred topics the program includes the following four core courses (3 credits each):

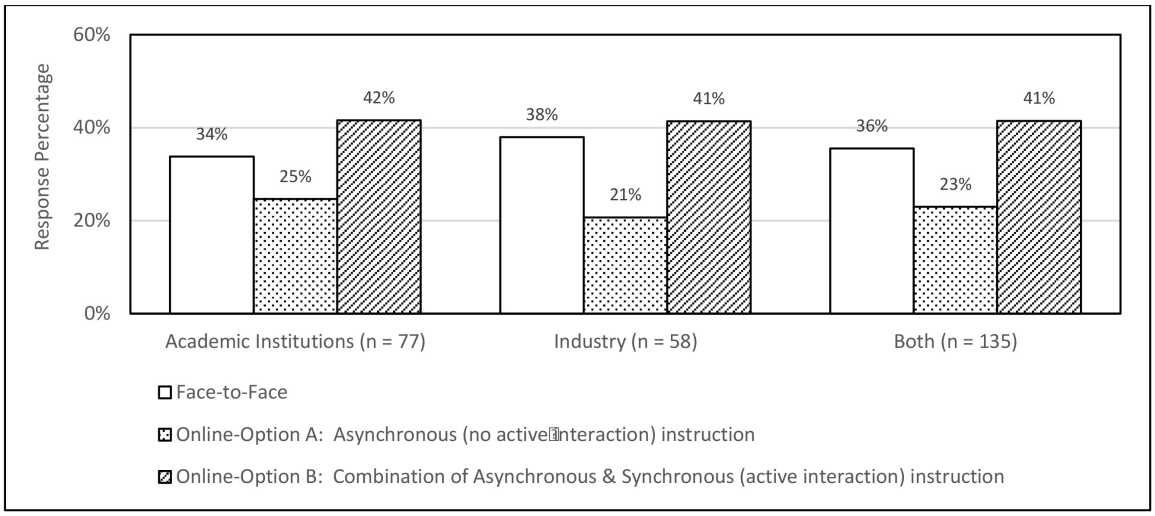


Fig. 4. Preferred Delivery Method for Engineering Education Professional Development Program.

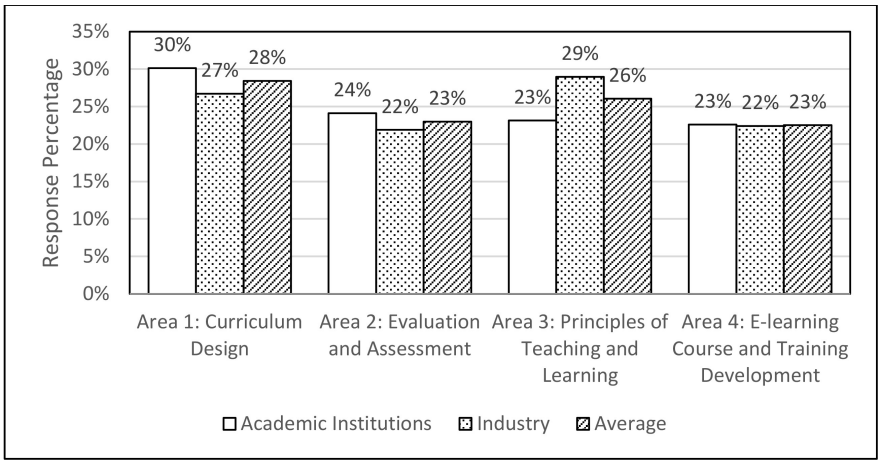


Fig. 5. Weighted Ranking of Preferred Topics Covered in Engineering Education Professional Development Program.

- Principles of Engineering Teaching and Learning,
- Assessing Learning and Teaching in Engineering,
- Engineering Course Design, and
- E-learning Course and Training Development in Engineering.

The objectives of all four core courses are presented in Table 2.

The objectives for each of the four core courses were created through an iterative process that first involved creating 5 to 10 draft objectives for each course that were loosely based on the course materials, course content, and course objectives for similar classes in the Engineering Education Ph.D. program. Since there is not a specific Course Design class in the Ph.D. program, the draft objectives for that course were created based on the educational experience of the two members of the curriculum team. These draft objectives were then presented to the full team and discussed. There was a significant amount of discussion and debate, since each member of the group had his/her own opinions based on his/her own educational and teaching experience.

Based on the discussion in the meeting of the curriculum team, the draft objectives were refined, combined, or eliminated and other objectives were proposed based on the experience and opinions of the members of the team who had previously taught similar courses in the Ph.D. program. A consensus was reached by the team and approximately five objectives were created for each of the four core courses. To proceed, members of the curriculum team held individual meeting, especially those who had most recently taught similar courses to begin to create specific course content for each of the courses for the certificate program.

Based on the objectives that were decided by the curriculum team, individual meetings were held to identify the specific course material (textbook,

Table 2. Core Courses in Proposed Graduate Certificate Programs in Engineering Education

Course	Description	Objectives
Principles of Engineering Teaching and Learning	Course focuses on the practical application of educational theories in teaching engineering. Theory focused topics in the course that will be covered include psychological types, theories of cognitive development, and learning theories. The practical topics include one-to-one teaching and advising, teaching efficiency, learning objectives, textbooks, lecturing, active learning, labs, and professional concerns for new professors. This course also includes tips for teaching design, ethics, problem solving, and creativity.	• Justify the importance of learning, as the aspects of quality and efficient teaching. • Explain the different learning theories, psychological types, and models of cognitive development applicable to engineering. • Discuss appropriate one-to-one teaching and advising techniques. • Develop learning objectives that align to given student learning outcomes and that focus on certain teaching strategies. • Discuss teaching ethics found within education. • Apply effective classroom/laboratory management in particular incorporate team activities/projects, and other practical skills course/training. • Apply effective communication and presentation skills. • Discuss professional concerns implicit to obtaining and working in academia; obtaining an academic position and the tenure process.
Assessing Learning and Teaching in Engineering	Course focuses on the assessment of not just of student learning but also of teaching in engineering education. Topics covered include the nature of student assessment, validity and reliability in assessment, and grading and reporting. The course will also focus on practical tips for creating selection-type, supply-type, and performance assessments that are tied directly to specific learning objectives.	• Develop an understanding of the history of student assessment and how it can impact student learning. • Discuss the differences between norm and criterion referenced assessment. • Describe and assess validity and reliability in the context of assessments and assessment planning. • Given provided learning objectives and standards, design and develop appropriate assessments that align to instruction techniques (focus on appropriate taxonomy in interpreting the objectives). • Understand the advantages and disadvantages (objectivity and subjectivity) of the major types of assessments as well as guidelines for their use and create appropriate selection, supply, and performance assessment items (i.e. questions). • Use appropriate ethical interpretation and scoring methods to effectively grade and report student performance. (t-scores, z-scores, and descriptive statistics). • Use assessments and action research to inform teaching practice.
Course Design in Engineering	Course focuses on practical tips for designing an engineering course. Specific topics covered include the creation of learning objectives, syllabi, and lesson plans, as well as the use of learning management systems in a course.	• Design learning objectives that are appropriate, student centered, measurable, and aligned with standards (e.g., accreditation). • Use learning objectives in ways that facilitate student learning. • Design instruction to allow for a variety of student learning styles. • Use learning management systems to facilitate face-to-face instruction. • Design an effective syllabus and lesson plans for classes and labs. • Identify useful learning resources.
E-learning Course and Training Development in Engineering	Course focuses on evidence-based best practices for designing and teaching a course in an online or distance environment. Topics include the application of learning theories to e-learning and the emerging educational theories specifically related to e-learning. The major focus of the course is on how to establish teaching presence, social presence, and cognitive presence in an e-learning course.	• Recognize differences between face-to-face and online learning environments. • Understand learning styles and evidence-based practices for online education. • Strategize to identify and tailor online instruction to the training needs of your audience. • Create an online teaching, social, and cognitive presence. • Understand the fundamentals of learning management systems.

papers, etc.) that would be used for the course. Material that did not fit into the course objectives was not to be included in the course. Other material was deemed important enough to be included in the course, so additional course objectives were created or existing course objectives were modified further. These changes resulted in the objectives shown in Table 2.

The program is intended to be delivered purely online with a combination of synchronous and asynchronous instruction and will take approximately one calendar year to complete.

Table 3. Program Structure for the Proposed Graduate Certificate Programs in Engineering Education

Course	Short Description	Credit Value
Principles of Engineering Teaching and Learning	Learning theories, desirable characteristics, attributes, learning principles, and various instructional/training methods applied in engineering education.	3
Assessing Learning and Teaching in Engineering	An overview of the various methods used to measure and evaluate learning in engineering teaching.	3
Course Design in Engineering	Developing educational or training engineering curricula, including the development of learning objectives, and choosing effective teaching methods.	3
E-learning Course and Training Development in Engineering	Review of learning theories and research for development of online engineering teaching and learning modules.	3
Teaching Internship	Capstone activity for students to gain experience, improve understanding of engineering teaching, reflect on own teaching, and obtain feedback from faculty members, colleagues and possibly students.	1
	Total Credits:	13

Apart from the four fundamental courses listed above, the program also features a Teaching Internship in Engineering Education that covers the application of concepts and skills learned from the core courses into teaching, self-reflection on teaching, and the preparation of a teaching portfolio. The final program structure is presented in Table 3.

4. Selection of online delivery method and considerations for graduate certificate program in engineering education

From the needs assessment survey, it was clear that the preferred delivery method for the Graduate Engineering Education Certificate was a mixture of synchronous and asynchronous online delivery. Asynchronous learning, commonly facilitated by media such as e-mail and discussion boards, supports work relations among learners and instructors, does not require students and instructors to be online or in person at the same time for instruction [33]. Synchronous learning, commonly supported by media such as videoconferencing and chat, refers to a learning event in which a group of students is engaged in learning at the same time.

There are significant advantages to the online delivery method. Violante and Vezzetti [34] stated some of these advantages: "It is easier for a large number of participants to successfully and more completely acquire instructional content [and] decreased expenses and waste of time of the students for traveling to the class venue". Thus, it is predicted that a fully online certificate program would be advantageous in order to reach a much wider audience than would be available with a face-to-face program.

There are also educational advantages, the major one related to the concept of "anywhere, anytime" and just-in-time access to information which allows the students to have 24-hour access to the information from almost anywhere in the world [35]. It also allows a student to work at a personal pace without intimidation, with learning becoming a continual process rather than a distinct event. Those advantages are mainly related to asynchronous approach, by simply introducing some number of online sessions. However, such method may be short on providing students with a satisfactory learning experience.

Although the reach of the program may be significantly increased due to an online delivery method, the fully online aspect of the program does introduce some challenges. For examples, the wide reach introduces time zone differences, which could complicate the synchronous aspects of the courses. However, there may be additional problems not related to the logistic of the delivery but to education experience. On-line education may appear to be impersonal and giving both the students and instructors the feeling of isolation. That is also related to reeducation and delays in communication, if the method is asynchronous [36]. A concept of teaching reflections planned in the program should moderate such issues.

Since Utah State University already uses Canvas as its default Learning Management System (LMS), it was decided that the Graduate Engineering Education Certificate program would also be delivered through Canvas. Therefore, a Canvas course was created for each course. Because of the need for uniformity between the four courses, each of the Canvas courses uses the same template for the front page, the syllabus, and for all module, assignment, and discussion pages (Fig. 6).

The front page for each course has links to the welcome page for the course, the syllabus, the

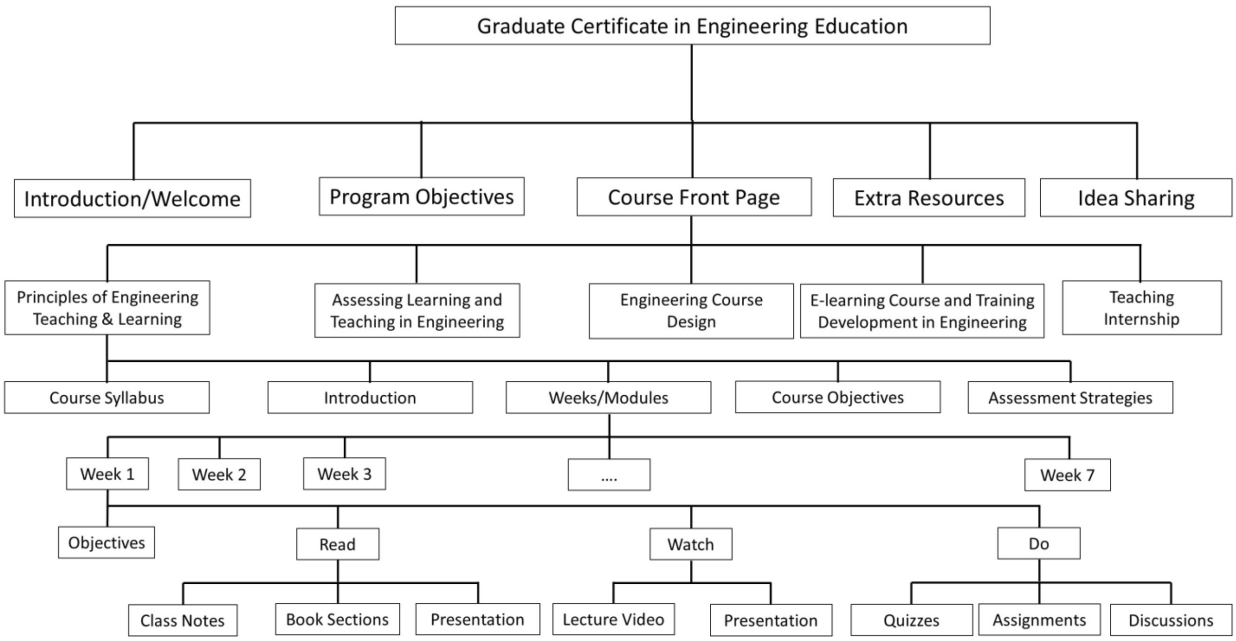


Fig. 6. Flowchart of the On-line Graduate Certificate in Engineering Education.

course objectives, the assessments, the weekly schedule, and a page for additional resources. In addition to each of these links on the front page, each of these pages can also be accessed using the Canvas navigation bar.

The page for each module (week) is divided into four sections: *Objectives, Read, Watch*, and *Do*. The objectives section includes the specific objectives for the week. The titles of the other three sections were created based on the desire for simplicity and clarity. The *Read* section includes the chapters/sections from the course material that need to be read for the week and a copy of the PowerPoint slides for the topics covered. The *Watch* section includes videos that the students can watch. These videos are created by the professor teaching the course and will be used for the asynchronous portions of the class. The synchronous portions may also be recorded and placed in this section for access later. The *Do* section includes a link to the assignment that needs to be completed for the week, a link to the discussion board for the week, and possibly a quiz. In addition to these sections, each module page has at least one multiple-choice question (Quick Check) that must be answered correctly in order to advance to the next module.

The assignment and discussion board pages are accessed from the front page, using the navigation bar on the left of any page in the course, or from the individual module pages. Each assignment page includes a detailed description of the assignment and in some cases, an example. The discussion pages include a description of the topic of discussed. Each assignment page and discussion page also includes a rubric used, not only for grading, but also to clearly communicate the instructor's expectations for the assignment/discussion.

With any program intended to improve teaching skills it is important to introduce a type of teaching practice to show that the students in the program have gained the necessary skills. Because of the online delivery method, it would be difficult to place the students in the certificate program into a teaching practice and to directly observe any teaching that would take place. To overcome these difficulties a teaching internship course was developed to accomplish the same goals as an in-person teaching practicum.

5. Addition of a teaching internship experience in the graduate certificate in engineering education

Since the online delivery method makes direct observation of teaching more difficult, a teaching internship course was designed as an essential part of the program. The course is intended to require students participating in the program to have some sort of teaching responsibility in engineering or an industry training environment.

The purpose of this teaching internship course is to be a capstone activity that gives the participants the opportunity to demonstrate the skills taught in the four core courses in the program. The teaching internship course includes the compilation of a teaching portfolio and a series of reflections by the participants on their own teaching.

The objectives of the teaching internship course are:

- to contrast critically student's teaching experience with theoretical knowledge gained in courses of the program,
- to learn from teaching experiences by using own reflections, students and faculty feedback,
- to present teaching credentials by demonstrating teaching methods and approaches, and by analyzing evidence of student learning,
- to be able to justify the choices of teaching methods and activities,
- to document professional development and to identify areas for improvement,
- to assemble a teaching portfolio that highlights the quality and scholarship of one's own teaching in a presentable form, also for hiring purposes.

5.1 Teaching portfolio

Rather than focusing on specific deliverables, the participants in the teaching internship course will be required to submit a teaching portfolio. The teaching portfolio is to be a collection of good teaching practices [37]. It should also provide information on teaching goals with reference to student teaching philosophy. It is important element of collecting evidence of student's teaching experience and effectiveness, especially in case direct observation is not possible.

Based on the reading material and their own experiences and thoughts, the portfolio will be space for the students to:

- present a teaching philosophy,
- present teaching methods & approaches,
- prove achievement of teaching skills,
- document professional development,
- identify areas of improvement.

Portfolio should provide materials (videos, written papers, and other documentation) that show competence in a set of skills based on the content of each of the core courses as presented in Table 4. Some of these materials are included as assessments elements in the courses and will only need to be submitted again (and possibly modified) as a part of the portfolio.

5.2 Teaching reflections

In order for the participants in the program to think about their own teaching, the teaching internship course will require participants to submit a biweekly reflection on their own teaching. The reflections are important tool in improving students' awareness and capability to monitor their own thinking, understanding and knowledge about their teaching [38]. The ability to reflect on their own teaching helps to identify a situation or issue in their teaching, and help them with about how to proceed in teaching practice.

The self-reflections on teaching experiences will be shared online with the other participants in the program. Each participant will also be required to comment on each other's reflections.

Teaching reflections should encourage the students to think about their own teaching. That should include collecting, recording and analyzing what happened during their teaching so they can make improvements to their teaching strategies. Teaching reflections through comments from other students will also create an online learning community that will allow the participants in the certificate program to share in each other's teaching experiences and insights.

5.3 Teaching internship online

Teaching Internship course will be offered, as the other courses, on Canvas. However, since that course is to be completed by students throughout the program, its page will be open from the beginning. Also, rather than being divided into weeks, it will have tabs related to its content, i.e. Reading, Teaching Reflections and Teaching Portfolio.

Readings will be included as a part of the teaching internship and will be scattered throughout the whole program. Teaching Reflections will need to be turned in every two weeks (biweekly) and will give the opportunity for the students in the program to think and write about their own teaching. Teaching Portfolio will involve the submission of documents, pictures, videos, etc. that will show mastery of the required skills. Many of these will be included as assignments in the other courses, which is why the Teaching Internship course should be opened from the beginning of the program. Although, the material for the Teaching Internship, including Portfolio and Reflections, will be accumulated regularly and continuously, therefore some review by faculty and comments from students will do happen, the final assessment for the course will be done at its end.

6. Conclusions

The paper describes the development of an online, graduate engineering education certificate program. The process for creating this online engineering education graduate certificate program began with a survey that was sent to people both in academia and in the engineering industry regarding engineering education training. The results of the survey showed that a one-year online engineering education graduate certificate program was preferred over other options. The survey also showed that there was about the same amount of interest shown

Table 4. Skills to be Demonstrated in Teaching Portfolio

Skills	Details	Examples
General Teaching Skills		
Organizational Skills: Classroom Management & Organization	• Use of rules, procedures, and routines to ensure active involved of students. • Expectation of student behavior.	Course syllabus or schedule; lesson plan, video.
Stimulation of Learners: Motivate & Attract Learner(s)	• Setting objectives, goals and expectations. • Use different teaching methods. • Create challenging assessment.	Video; include in Teaching Philosophy.
Conflict Resolution	• Communicate effectively; express & listen • Consider options • Attempt to find a win-win solution	Video; include in Teaching Philosophy.
Rapport with Students	• Respect students & their culture. • Lead with positive emotions. • Interact & reward.	Video; include in Teaching Philosophy.
Help learners to develop soft skills	• Communication skills. • Independent learning, interdependent learning, & lifelong. learning skills. • Emphasizing issues related to globalization, environment & social responsibility.	Video; include in Teaching Philosophy.
Principles of Teaching and Learning		
Communicate Expectations Clearly	• Define clearly objectives. • Specify syllabus with expectations, assignments, assessments methods.	Course Syllabus that includes objectives, assignments, tentative schedule, etc.
Presentation skills	• Speaking & explaining clearly. • Holding the students' attention. • Highlighting important points. • Presenting appropriate examples. • Encouraging questions. • Seeking active student involvement beyond simple questioning.	Video.
Monitor learning	• Plan instruction. • Monitor & communicate performance. • Respond to needs.	Video; include in Teaching Philosophy.
Use of instructional methods relevant to engineering education & showing instructional development	• Student-centered approach. • Cooperative & Collaborative Learning. • Active Learning.	Video.
Emphasizing development of critical & problem solving skills	• Critical thinking. • Problem solving. • Creativity.	Video; include in Teaching Philosophy.
Incorporate Learning in Engineering Work Settings	• Information retrieval & revision, processing data, scientific enquiry. • Technological development & integration of disciplinary knowledge. • Laboratory courses. • Learning practical skills. • Learning in groups & teams. • Formal & informal learning.	Video; include in Teaching Philosophy.
Design Teaching	• Case Study, Design Studies, & Action Research. • Final project.	Sample assignments.
Evaluation & Assessment		
Check for Understanding	• Use formative assessment. • Observe. • Use feedback & feed-forward.	Video.
Responsive Teaching	• Instructional Engagement. • Multicultural Awareness. • High Expectations.	Video; include in Assessment Philosophy.

Table 4. (*cont.*)

Skills	Details	Examples
Evaluation & Assessment (*cont.*)		
Provide Productive Feedback	• Provide feedback to promote learning. • Provide regular accessible, clear, legible & unambiguous feedback. • Wherever possible use formative assessment.	Examples of actual feedback to learners (if available); Sample feedback to hypothetical learners.
Showing effective assessment & evaluation	• Complete tests & individual test items. • Laboratory reports, design project reports, live or videotaped oral. presentations, research proposals.	Sample assessments.
Showing effective and ethical grading and reporting practices	• Use an effective and fair grading system. • Ethical reporting of grades. • Ethics and fairness in making changes to grades.	Completed grading assignment from Assessment course, include in Assessment Philosophy.
Encouraging peer & self-assessment	• Critiques of technical reports, papers, letters, & memos. • Peer Evaluations. • Self-evaluations, learning logs, journals.	Video; include in Assessment Philosophy.
Curriculum Design		
Course design	• Identify desired results. • Determine acceptable evidence. • Plan learning & instruction.	Learning objectives, planned activities & assessments.
Syllabus design	• Course content. • Learning objectives. • Logistics: schedule of topics and readings, assessment.	Course Syllabus that includes schedule, objectives, textbooks/readings.
Preparing a class: create a Class/Training Session	• Lesson plans including specific topics covered. • Use of learning management systems.	Class or training plan.
Technology & Learning		
Use of Online Element	• Application of online elements of teaching & learning.	Incorporate ELMS, Blackboard, Box, website/blog, etc. into a class or training.
Use of appropriate technology	• Application of suitable technology to demonstrate/explain/clarify/illustrate. engineering example/problem.	Video.
Establishing Social Presence in an online environment	• Establish a supportive learning community. • Create a trusted environment for communication.	Sample discussion boards and other communications, include in teaching philosophy.
Establishing Teaching Presence in an online environment	• Design, facilitation, and direction. • Serving as a guide to student learning.	Video, lesson plan, include in teaching philosophy.
Establishing Cognitive Presence in an online environment	• Helping students to reflect and construct meaning.	Video, lesson plan, include in teaching philosophy.

in each of the four proposed focus topics: Principles of Teaching and Learning, Evaluation and Assessment, Curriculum Design, and E-Learning Course and Training Development.

Based on the results of the study, three-credit courses for each of the topics from the survey were created. The initial focus in the design process was on the basics of each course that were necessary for approval by the administration. For each proposed course, learning objectives from the broad topics from the survey were created. In addition to the learning objectives, a brief description for each

course and proposed possible course material were written.

In addition, a teaching portfolio was introduced as a capstone activity for students in order to demonstrate mastery of the specific skills taught in four courses listed above. The online medium makes a direct observation of teaching more difficult, so instead of having direct observation of teaching, a combination of a teaching portfolio and regular teaching reflections was considered to be sufficient substitute for direct in-person observation.

The program has been approved by the administration at Utah State University and is reaching the final stages of the preparation. In order to have consistency throughout all four courses, a basic skeleton structure was designed in a learning management system. This basic structure is used as a template for all four courses once specific course content and material was created. The process of creating material for courses is on-going. Specific course content has been developed including assessments/assignments and discussion topics for each week. For some of the courses, these assessments and discussion topics have not evolved beyond the initial idea phase as of yet, but will be completed in time to teach the courses as scheduled. Some of the asynchronous lectures have been completed in the form of PowerPoint presentations, but the accompanying videos are still in the process of being created. There will also be synchronous portions of the courses, which are in the planning stages. It is envisaged that synchronous sessions will be recorded to allow the participants to view them again. Additional information about the program can be found on the website that has been created for this certificate program: https://eed.usu.edu/programs/ceed/.

The proposed program intends to be accessible worldwide giving more engineering educators an opportunity to broadly apply evidence-based practices into their workplace or learning environments. The program targets current and future engineering educators and trainers, both in academia (community colleges and universities) and industry. Potential candidates should have an undergraduate degree in any engineering discipline. The goal is to improve the quality of the teaching and training in engineering by empowering students to become better and more knowledgeable engineering instructors with understanding of educational theories and their applications.

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Jacek Uziak is a Professor in the Department of Mechanical Engineering of the University of Botswana. He received his MSc in Mechanical Engineering from the AGH University of Technology in Krakow, Poland and his PhD in Technical Sciences from the University of Life Sciences in Lublin, Poland. For the past 35 years he has been working at universities mainly in Poland and Botswana; his career includes teaching and research assignments also in Canada, Czech Republic, Norway, UK, Netherlands, France, Germany and USA. He specializes in engineering mechanics and teaches courses in this area. He has particular interest in engineering education.

Ryan Barlow is a PhD student in Engineering Education at Utah State University where his research focuses on continuing professional development of engineering educators. He obtained his Bachelor's Degree in Mechanical Engineering from the University of Utah in 2012 and his Master's Degree in Science Education from the University of Maryland in 2016.

Idalis Villanueva is an Assistant Professor in the Engineering Education Department and an Adjunct Professor in the Bioengineering Department in Utah State University. Her multiple roles as an engineer, engineering educator, engineering educational researcher, and professional development mentor for underrepresented populations has aided her in the design and integration of educational and physiological technologies to research "best practices" for student professional development and training. In addition, she is developing methodologies around affective management of curriculum and instruction in engineering students.

Oenardi Lawanto is an Associate Professor in the Department of Engineering Education at Utah State University, USA. He received his BSEE from Iowa State University, his MSEE from the University of Dayton, and his PhD from the University of Illinois at Urbana-Champaign. Before coming to Utah State, Dr. Lawanto taught and held several administrative positions at one large private university in Indonesia. He has developed and delivered numerous international workshops on student-centered learning and online learning-related topics during his service. Dr. Lawanto's research interests include cognition, learning and instruction, and online learning.

Kurt Becker is a Professor in the Department of Engineering Education at Utah State University where his research focus is in the area of engineering design thinking. He currently is working on a National Science Foundation (NSF) funded project quantifying differences between professional expert engineers and engineering students designing. His other areas of research include adult learning cognition, engineering education professional development and technical training. He has extensive international experience working on technical training and engineering projects funded by the Asian Development Bank, World Bank, and US Department of Labor, USAID. Countries where he has worked include Armenia, Bangladesh, Bulgaria, China, Macedonia, Poland, Romania, and Thailand. In addition, he teaches undergraduate and graduate courses in engineering education for the department.